

T E R R A

JULY / AUGUST 1998
VOLUME 35 ■ NUMBER 4

NATURAL HISTORY MUSEUM OF
LOS ANGELES COUNTY



PIT 91 REOPENS

The search for *all* the fossils continues

IN EARLY JULY, WHEN THE EXCAVATION of Pit 91 in Hancock Park reopens, it will be the twenty-sixth season of paleontological exploration of this particular deposit. One of the questions most frequently asked by visitors to the Page Museum of Rancho La Brea Discoveries is, "Why are you still digging in Pit 91 when you already have so many fossils from the Rancho La Brea deposits?" The simple answer is that we have not yet retrieved all the information for which the excavation was started in the first place.

Most of the bones currently on display in the Page Museum or maintained in the storage ranges that surround its public areas, were collected between 1913 and 1915, by the staff of what was then the new Los Angeles County Museum in Exposition Park. Captain G. Allan Hancock, owner of Rancho La Brea, had given the museum the sole right to excavate in the asphalt deposits for a period of 2 years.

During this early excavation, the museum staff explored about 100 different localities within the 23 acres that now make up Hancock Park. About half the excavations yielded fossils, and more than a million bones were unearthed in the allotted interval.

In contrast to J.Z. Gilbert (see pages 4 and 5), who had been concerned with all fossils large and small when he excavated at Rancho La Brea between 1908 and 1910, the people conducting the 1913 to 1915 digs concentrated mainly on the "trophy specimens," such as complete skulls and long bones of the larger extinct mammals and birds. Incomplete or poorly preserved larger bones were often discarded, as were some smaller elements of the more abundant larger fossils, such as toe bones of dire wolves and coyotes.

Given the speed at which the excavations took place and the emphasis on the larger and more spectacular specimens, it was inevitable that the remains of smaller creatures such as shrews and rodents were

entirely overlooked. Indeed, for many years our knowledge of the fossil rodents from Rancho La Brea was limited to the specimens fortuitously preserved inside the skulls of some of the larger mammals.

Not only did the earlier excavations provide a rather biased impression of the diversity of animals preserved in the asphaltic deposits, they gave a less than optimum interpretation of the habitats that were present in the Los Angeles Basin at the time the deposits were forming.

For example, remains of larger grazing mammals, such as horses, bison, mammoths, and Harlan's ground sloths, were more common in the deposits than those of browsing animals—the mastodons, deer, peccaries, and Shasta ground sloths, and this could suggest that forests were absent from much of the Los Angeles Basin at that time. However, the larger mammals are capable of migrating scores

if not hundreds of miles during the course of their lifetimes, and their presence or absence or relative abundance in an area is not a precise indication of particular environmental conditions. In contrast, rabbits, rodents, snails, and other small creatures occupy much smaller territories and can more accurately represent prevailing climate and vegetation.

Thus in the late 1960s, more than a half of a century after the museum's first excavations, its paleontologists decided to start a new dig, this time concentrating—as Dr. Gilbert had done—on all the vertebrate fossils and not just the larger ones. They also sought to document the diversity of invertebrate and plant remains.

WORKERS HAD DISCOVERED that there were fossils in Pit 91 in 1915, but they left the pit unexcavated on the premise that it could be used for a public



exhibit, to demonstrate what fossils looked like when left in place in the ground. However, the nearby Pit 101 was eventually used for this purpose: a viewing station there, dedicated to former curator Chester Stock, was opened to the public in 1952. And so the Pit 91 accumulation was readily available for the new excavations, which began in 1969 under the leadership of George Miller. A level datum was established as a point of reference for the ensuing excavation, and the surface of the fossil deposit was divided into a 3-foot-square grid system. (As now, the metric system was then the standard for scientific measurements, but Mr. Miller decided to use English units to be consistent with the records made during the 1913–1915 excavations.)

Each grid square was excavated in 6-inch “spits” (to a depth of 6 inches at a time). The orientation of any identifiable bone longer than a quarter of an inch was recorded and plotted in the hope that comparable measurements for all the larger bones could shed some light on how the deposit had accumulated. The larger and readily discernible bones were removed from a spit by hand. Then the remaining mass of matrix was removed and treated with 1–1–1 trichloroethane, which dissolves the asphalt to leave behind sand grains, pebbles, and microfossils. Samples of untreated matrix were also stockpiled for pollen analyses.

THE PIT 91 EXCAVATION continued year round from 1969 through 1979, with funding from the National Science Foundation and the Natural History Museum Foundation, and reached a depth of about 12 feet below ground level. Although work was suspended for

lack of funding in January 1980, we excavated again for 2 months in 1984, to celebrate the Los Angeles Olympics, and we have continued to dig for 2 months each summer ever since. The reopening of the pit each year has become a widely anticipated event, giving park visitors the opportunity to observe paleontological field work in the middle of a major city and attracting attention from the press across the country.

The pains taken with the new excavations have been well worthwhile. We now know that more than 650 species of animals and plants were present in the Los Angeles Basin between 11,000 and 40,000 years ago, making Rancho La Brea one of the most diverse fossil assemblages in the world. Most of what we know about the plants, mollusks, insects, fish, amphibians, and reptiles is derived from study of the material recovered from Pit 91, and there is much material, particularly microfossils, yet to be studied.

The microfossils have indeed given us insight into the climate that prevailed while the Pit 91 deposit was accumulating. Minute land snails recovered from the asphaltic horizons are today found only at elevations above 5,000 feet in the mountains of California and Arizona; their presence at Rancho La Brea con-

firms that the climate of southern California was cooler and more humid in the past than it is today. The fossil plant assemblages document four distinct habitats—chaparral, deep canyon, coastal sage scrub, and riparian. They include many species that are no longer found in the region, and the riparian species

document the presence of permanent streams on the coastal plains.

HOW MUCH LONGER will the excavation continue? The fossils from Pit 91 are believed to be around 28,000 years old, making the pit one of the few Rancho La Brea accumulations of asphaltic deposits that predates the peak of the last glacial interval, and so it would be nice to extract as much material and information as possible. It is estimated that the deposit extends downward for at least another 3 feet; this depth could be reached in 2 years of year-round excavation, but another 15 to 20 years will be required if digging is restricted to 2 months each summer.

At this juncture we are not anxious to press ahead full time with the excavation because of the considerable backlog of matrix that still has to be treated. Our standard solvent, trichloroethane, is an ozone depletent and will shortly be taken off the market. Meanwhile, with the aid of the Institute for Research and Technological Assistance of West Los Angeles, we



COVER AND PAGES 2 THROUGH 4: Views of Rancho La Brea and the Lake Pit, circa 1910. Glass lantern slides from the Gilbert Collection, Page Museum Archives, Natural History Museum of Los Angeles County.



are nearing the end of a search for a replacement process. We have identified the new method to use, but it will take some time, and additional funding, to be able to complete preparation of samples already accumulated.

Is this the last incompletely excavated fossil deposit at Hancock Park? By no means. The 100 sites explored in the 1913–1915 frenzy of activity were located by surface expressions of asphalt: the museum's prospectors searched for exposures of oxidized asphalt and sank an excavation wherever these were found. The potential for finding other asphaltic deposits below the surface is very high.

In the course of the renovation of Hancock Park now underway, one new deposit 2 feet below the surface has already been found. Will we excavate this? Perhaps in the future, but not now. The deposit is deep enough that a new path for park visitors can be placed above it without disturbing the fossils. And so we have made careful notes of where it is and

have left it for the attention of the scientists of the future, who will be able to use new methods to test new hypotheses about Los Angeles's prehistoric past.

JOHN M. HARRIS
Chief Curator, Paleontology

Dr. Harris, an expert in fossil herbivorous mammals, is currently studying the diets of some of Rancho La Brea's large mammals (see page 9). In addition, with Dr. Blaire Van Valkenburgh of UCLA and Dr. Lillian Spencer of Duke University, he has recently been awarded a National Science Foundation grant of \$165,000 for an analysis of the nature of the fossils entombed in Pit 91 and the ways in which bones accumulated there. Under the new grant, the three scientists will examine Pit 91 fossils for damage that occurred at or just after an animal's death and that may have been caused by carnivores or rodents, insects, or trampling by large mammals.

"Worth More to Los Angeles Than Gold Mine"

What a changed view of earth's fauna is presented in the survey of the hidden treasures of these tar beds. The light thus far shed is pleasing and intensely interesting, yet . . . here the night of unsolved mysteries is only deepened.

James Z. Gilbert, *Bulletin of the Southern California Academy of Sciences*, January 1910

THIS OBSERVATION, FROM THE concluding remarks of James Z. Gilbert's 40-page article, "The Fossils of Rancho La Brea," reveals some of the profound curiosity and excitement that infused his studies of the asphalt deposits in what is now Hancock Park in the first decade of the century. Although the prehistoric quality of the bones embedded in the tar pits had been suspected since at least 1875, Dr. Gilbert was the first to conduct relatively large-scale and sustained excavations at Rancho La Brea. The fossils he unearthed were used in one of the most popular exhibits on view in our Exposition Park museum when it opened to the public in 1913. And they now form a significant part of the Natural History Museum's holdings from Rancho La Brea and are represented among the collections and displays of the Page Museum of La Brea Discoveries.

James Z. Gilbert brought scientific education and expertise to his work at Rancho La Brea. Born in North Manchester, Indiana, in 1866, he graduated from Kansas's McPherson College in 1894; he then studied paleontology under S.W. Williston at the University of Kansas, where he obtained a master's degree in 1895. After serving as a high school principal, and as president of Daleville Normal College in Virginia, he accepted a position as a science teacher at Los Angeles High School in 1904.

In September of 1907, Dr. Gilbert was leading a field trip near the tar deposits (then on the western outskirts of the City of Los Angeles) when a partially

exposed skull caught the attention of one of his students, Harry Hager. Like so many people who had noticed bones in the asphalt in preceding years, Mr. Hager presumed it to be from a domestic animal—a sheep, perhaps. But Dr. Gilbert examined it and realized that it belonged to no modern species. A few days later, he returned to the site after school to complete the tedious work of retrieving the specimen, which he identified as the skull of a lion, "of African type, *Felix atrox*." Over the next few months he retrieved other fossils from the site, with the permission of the property owner, Madam Ida Hancock Ross, the mother of G. Allan Hancock.

As Chairman of Zoology for the Southern California Academy of Sciences, Dr. Gilbert brought his finds to the attention of his colleagues there. Under the auspices of the academy, he soon obtained permission for more extensive excavations. Under Dr. Gilbert's direction and with funds from the city and county as well as private donations, efforts continued for more than 2 years to remove, identify, and mount fossils from the site.

Much of the excavation was done by Dr. Gilbert's high school students, working alongside their teacher on Saturdays and during their vacations—the boys digging, the girls washing the tarry bones in kerosene. "It is a rare opportunity for Los Angeles students to have such a bed of fossils so near the city," he said. Hundreds of people visited the area to watch the excavations; headlines from one of a number of newspaper stories about the project give further indication of the excitement the dig provoked: "The La Brea Pits Revelations; Unique Addition to Science by Prof. Gilbert; Marvelous Find of Rarest Fossil Remains."

The Rancho La Brea material that Dr. Gilbert excavated for the Academy of



J.Z. Gilbert, with his wife, Harriet Yoder Gilbert, and their children, from left, Harry, Walter, and Mary, circa 1910. Mary Gilbert Sheller, now 95 and living in North Manchester, Indiana, recalls traveling as a small child to the end of the trolley line with her father and then walking another mile or so to help with the dig at Rancho La Brea. Photograph courtesy of the Gilbert family.

Sciences, one of the founding organizations of our institution, was the fifth collection accessioned by the museum. He also amassed fossil holdings for Los Angeles High School; several mounted skeletons were created from this material and subsequently donated to the museum. The fossils remaining at the school were used in courses on paleontology.

In the years following his Rancho La Brea excavations, Dr. Gilbert worked to sort and identify the thousands of specimens he had uncovered. Mastodon bones and dermal scutes of giant ground sloths as well as tiny bird bones were each meticulously marked with an identifying code and itemized in his record books. When a newspaper reporter asked why he bothered with the smallest bones, some hardly larger than a toothpick, Dr. Gilbert replied that among all the fossils, there might be only one bone remaining from a certain species—if it was overlooked in favor of those from the larger and more dramatic creatures, the record of an animal

could be lost forever.

Dr. Gilbert continued to teach at Los Angeles High School until his retirement in 1938; he was also an instructor at LaVerne College and at USC's School of Dentistry and published scientific papers on various subjects. He was a close colleague of several eminent scientists of his time, including John Muir; with ichthyologist and Stanford University president David Starr Jordan, he coauthored two works on fossil fish.

In 1919, Dr. Gilbert was awarded an honorary doctoral degree from McPherson College. He remained active in the Southern California Academy of Sciences and was elected an honorary life member shortly before his death in 1945.

RECENTLY ELEVEN DESCENDANTS of James Z. Gilbert—his daughter, Mary, and his grandchildren and great-grandchildren—have donated the family's collection of photographs relating to excavations at Rancho La Brea to the Natural History Museum of Los Angeles County. These early records, which include the photographs on the cover and pages 2 through 4 of this issue of *Terra*, show a Los Angeles with the space between Wilshire Boulevard and the Santa Monica Mountains punctuated by oil derricks, at a time when Dr. Gilbert was in the process of uncovering a collection headlined in a newspaper account as "Worth More to Los Angeles Than Gold Mine."

Dr. Gilbert was a pioneer in recognizing the importance of the asphalt deposits and in organizing and documenting an early excavation there. The gift of his descendants, now preserved in the archives of the Page Museum, will be an invaluable resource to scholars studying Rancho La Brea and Los Angeles in the early twentieth century.

MAMMAL ENAMEL

Diet leaves its mark in the fossil record

MY COLLEAGUE THURE CERLING, Professor of Geochemistry at the University of Utah, likes to tell his students, "You are what you eat." He proved it on a recent 3-week trip to Inner Mongolia by shaving his beard daily and saving the whiskers in sterile polyethylene containers. Upon his return to Salt Lake City, he analyzed the hair samples in a mass spectrometer and was able to demonstrate that his body chemistry had changed dramatically while he was in Asia, that the changes were reversed upon his return to the United States, and that they were directly related to the food he ate and the liquids he drank during the course of his journey.

For the past few years, Dr. Cerling and I have been working together examining the fossil record for clues to ancient environmental conditions. Using the principle that differences in diet are reflected by differences in body chemistry, we have been able to document some important changes through time in both the vegetation and climate of North America and East Africa, on the basis of the stable isotope geochemistry of mammalian tooth enamel.

STABLE ISOTOPE GEOCHEMISTRY sounds a bit of a mouthful but may be readily explained. We learned in high school about the periodic table—the list and arrangement of all elements known to exist in the universe. We are also familiar with the fact that some elements are represented by more than one form, or isotope. Carbon has at least three isotopes, known as carbon 12 or ^{12}C , carbon 13 (^{13}C), and carbon 14 (^{14}C).

Some isotopes are unstable and during the course of time change into another form. The transformation of an unstable isotope into another at a known rate is the basis for various radiometric dating techniques. However, in our studies of

carbon, Dr. Cerling and I were not interested in ^{14}C , the unstable isotope that is the mechanism for radiocarbon dating. Instead, we focused on ^{13}C , which is a heavy form of the more common ^{12}C .

Plants take up carbon during the process of photosynthesis, and one photosynthetic pathway, known as C_3 , is used by most trees and shrubs and by many grasses that grow in cool or temperate climates; corn or maize and Kentucky bluegrass are examples of C_3 plants. Another type of photosynthesis—the C_4 pathway—is used by grasses that grow in warm areas with summer rains; wheat and crabgrass are examples of C_4 grasses.

C_4 plants have more atoms of carbon 13 in their composition than C_3 plants, and this makes it possible to differentiate between C_4 and C_3 plants with chemical analyses. It follows that herbivorous animals that eat C_4 plants will have a higher proportion of ^{13}C in their body fluids than animals eating C_3 plants. This body chemistry is in turn passed on to carnivores that eat these herbivores.

The composition of the body fluids is reflected in an animal's hard parts, such as the bones and teeth. It is possible to analyze these parts of a recently dead mammalian herbivore—a horse or elephant, for example—and determine whether it had fed from C_3 or C_4 vegetation or from a mixture of the two. The teeth of carnivores can in

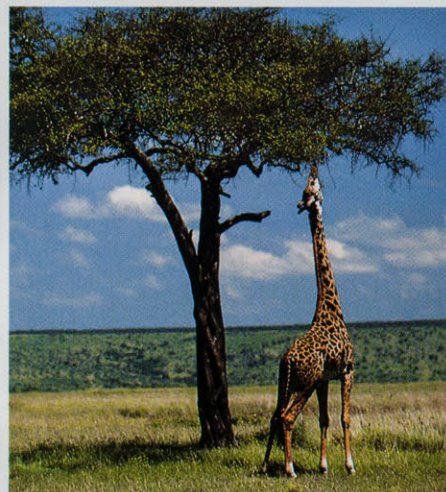
turn reveal whether they were eating animals that lived in woodlands and fed from C_3 vegetation or prey that grazed in C_4 grasslands.

Our analysis of recent mammals from East African game parks showed that wildebeest were eating more grass than zebras, and that elephants—which traditionally have been thought to be eating a lot of grass—were in fact subsisting mainly on leaves from trees and shrubs. As a control Dr. Cerling had previously analyzed the teeth of zebras, antelopes, and other mammals that had been fed alfalfa grass at Hogle Zoo in Salt Lake City; as expected, the teeth of mammals that had been eating the same foodstuffs had identical chemical composition.

THE BONES OF THE SKELETON and the dentine of the teeth are porous and, during fossilization, are subject to processes that alter both their physical structure and chemical composition. Tooth enamel, on the other hand, is a very dense and compact substance and is not impacted in the same way by fossilization. Dr. Cerling and I began to analyze the tooth enamel of fossil herbivores from different parts of the world. We hoped to be able to chart the worldwide spread of C_4 grasses that occurred at the end of

The Burchell's zebra and white-bearded wildebeest are grazers found in large numbers in the Serengeti Plain of East Africa. Herds of wildebeest migrate from pasture to pasture during the year, spending the dry

season near the shores of Lake Victoria but traveling to the southern Serengeti at the onset of the rains. Isotopic analysis shows that the diet of both zebra and wildebeest is exclusively C_4 grasses.



The Masai giraffe and gerenuk, or giraffe-necked antelope, are both browsers, feeding mainly on the leaves of *Acacia* trees. Isotopic analysis indicates that both animals derive the water they need from the vegetation they eat. Neither animal exploits the C_4 grasses that occur for at least part of the year in the habitats where they live.

PHOTOGRAPHS BY ART WOLFE

the Miocene Epoch, between 5 and 7 million years ago.

The first step in the actual analysis is to cut, pry, or otherwise obtain a piece of enamel from a fossil herbivore tooth. We found this to require not only manual dexterity and technical finesse but also a great deal of tact and diplomacy: most museum curators are understandably reluctant to unleash geochemists armed with hammers and chisels on their painstakingly amassed and priceless collections of fossils. We quickly learned to pacify our sources by using high-speed drills with diamond blades to cut small portions of enamel from parts of teeth that were not

readily visible and would not be needed for measurements or other analyses.

Once a sample is obtained, one has to clean any dirt and rock off the outside of the enamel and all traces of adjacent dentine off the inner surface. The next step is to grind the enamel into fine powder using a mortar and pestle. After treatment with bleach and acetic acid, to remove any organic contaminants, a carefully measured portion of the powder is dissolved in phosphoric acid to produce carbon dioxide gas. The captured gas is then analyzed in a mass spectrometer, which determines the proportion of carbon 13 present in the tooth enamel.

The results obtained from the mass spectrometer are a "twofer." In photosynthesis, plants take up not only carbon but also oxygen, in two distinct forms— ^{16}O and ^{18}O . In addition to learning the carbon composition—the proportions of ^{13}C versus ^{12}C —of a sample, we can also document the oxygen composition, the ^{16}O to ^{18}O ratios. Because the presence and proportion of the heavier oxygen 18 in the tooth enamel are related in part to temperature, ^{18}O may tell us something about ancient climates. And because ^{16}O evaporates more readily than ^{18}O , the ratio of the two provides a clue to the source of water used by a specific indi-

vidual. An animal drinking from a river or spring will show a smaller concentration of ^{18}O than an animal drinking from a lake, where the large water surface area promotes evaporation of the light ^{16}O . And an animal deriving all its water from the vegetation it eats will have the highest concentration of ^{18}O . Although oxygen isotopes have not yet been used extensively for looking into the environments of past epochs, we think that this kind of investigation has great potential.

THE OLDEST KNOWN EXAMPLES OF C_4 plants, from a fossil formation in Red Rock Canyon in California, are believed to be about 12.5 million years old. However, analysis of the tooth enamel of horses and other mammals of similar age from the canyon showed that, while C_4 plants may have been present, the herbivores were not eating them. It wasn't until about 5 million years later that C_4 grasses began to form a significant part of the diet of grazing herbivores. Then, as if in answer to a hidden signal, C_4 grasses became the diet of choice for horses and other grazing animals in the world's tropical and subtropical regions—North and South America, southern Asia, and Africa.

Evidence from the fossil record of North America indicates that there was a gradual northerly radiation of C_4 grasses during the late Miocene and earliest Pliocene. Horses adopted a C_4 diet in northern Mexico about 7 million years ago, in Arizona and Texas and the Gulf Coast about 1 million years later, and in the Dakotas and the Great Plains another million years after that.

Fossil evidence from East Africa suggests that different groups of mammalian herbivores there took advantage of the new C_4 food source sequentially. The horses and rhinos were the first to adopt a C_4 diet, followed by the elephants and most of their relatives, and then by the antelopes and pigs. The last animals to adapt to a C_4 diet were the short-necked giraffes, or sivatheres, which did not start eating C_4 grass until the late



The black rhino (left) browses on C_3 vegetation whereas its cousin the white rhino has adapted to feed on C_4 grasses.

Page 9: Here, an African elephant strains to reach a sprig of *Acacia*, a C_3 plant, while apparently ignoring the nice stand of C_4 grasses at its feet.

Elephants and mammoths have high-crowned teeth for feeding on abrasive grasses, and isotopic analysis indicates that these mammals were among the first to exploit the new C_4 grasslands during the Late Miocene. It is curious, therefore, that most modern elephants have only a small proportion of grass in their diet.

Pliocene, about 2.5 million years ago.

Not all representatives of a group changed their diet and lifestyle to take advantage of the expansion of C_4 plants. In North America, mammoths were C_4 grazers, but mastodons remained C_3 browsers at most locations. In East Africa the white rhinos began to graze while the black rhinos continued to browse; the elephants and related gomphotheres became grazers, but the deinotheres (tapirlike distant cousins of the elephants) remained browsers. The short-necked giraffes cropped C_4 grasses, but their long-necked relatives continued to browse from C_3 *Acacia* trees. When we compared the isotopic chemistry of giraffes and deinotheres from the same locality, we found that both were eating the same type of C_3 vegetation but that the deinotheres had been drinking from nearby streams while the giraffes were getting most of their water from the leaves that they ate.

WHAT CAUSED the worldwide shifts in vegetation between 5 and 7 million years ago, at the end of the Miocene Epoch? The conventional answer has been that the changes were by-products of the global cooling and increasing aridity that heralded the onset of the Pleistocene Ice Age. There is, however, an alternative interpretation: the radiation of C_4 plants could have been the result of a diminished concentration of atmospheric carbon dioxide.

Geochemical analysis indicates that the amount of carbon dioxide in the atmosphere has fallen dramatically from what it was 65 million years ago, at the end of the Age of Dinosaurs. One way in which carbon dioxide is extracted from the atmosphere is through reaction with rocks to form carbonates. Geochemists surmise that the uplift of the Himalaya mountain range and the Plateau of Tibet during the course of the Miocene, starting about 25 million years ago, increased the surface area of Eurasia and resulted in a corresponding reduction of atmospheric carbon dioxide.

What is also clear is that the C_3 photosynthesis pathway is promoted by high concentrations of atmospheric carbon dioxide, whereas the C_4 pathway is favored by low CO_2 levels. It is possible that, as a result of the major tectonic movements in Asia during the Miocene, global concentrations of atmospheric CO_2 fell to a level that fostered the C_4 photosynthetic pathway; this would have encouraged the sudden expansion of C_4 grasslands that we found documented in the tooth enamel of the mammalian herbivores of the time.

The expansion of C_4 grasslands and the consequent reduction of forests was accompanied by a major turnover in the terrestrial animals of Africa. The results were a rise to prominence of grazing mammals such as antelopes, hippos, and elephants, together with the flourishing of a lineage of bipedal apes, which forsook

the equatorial forests to take advantage of the newly open savannas.

Analysis of carbonates from fossil soil horizons at different Pleistocene localities suggests that the colder glacial intervals, with their lower concentrations of atmospheric CO_2 , promoted C_4 photosynthesis. This has a bearing on the extinction event at the end of the Pleistocene, when many of the larger mammals in North America and elsewhere disappeared.

The rise in CO_2 levels at the end of the last glacial period would have fostered another shift, this time from open grasslands to more forested conditions. This is borne out in Africa, where there was a dramatic change of the fauna at the end of the Pleistocene. Many large grazing antelopes and pigs became extinct, the browsing black rhino replaced the grazing white rhino as the predominant form, and the grazing elephant *Elephas* was replaced by the browsing African elephant.

DR. CERLING AND I have embarked on a program of analysis to see if stable isotope geochemistry can shed some light on the extinctions chronicled at Rancho La Brea, but our interpretations are still at a very preliminary stage. Today the coastal region of southern California enjoys a Mediterranean climate; winters are warmer than in much of the rest of the country, but because there are no summer rains, very few C_4 plants occur here naturally. We would therefore expect that mammalian herbivores living in the region during the last 20,000 years would have had a

pure C_3 diet. But preliminary isotopic tests on Rancho La Brea mammoths, mastodons, horses, bison, and camels indicate that all were eating a mixture of C_3 and C_4 vegetation.

There are several possible explanations for this somewhat surprising finding. We know that the bison were living elsewhere for part of the year and may have obtained much of the C_4 fraction of their diet from other locations. It is possible, however, that lower atmospheric concentrations of carbon dioxide during the last glacial period permitted the presence of at least some C_4 grasses in the Los Angeles Basin. Initial results suggest that horses and mastodons from the most recently formed deposits at Rancho La Brea were eating more C_3 vegetation, which ties in nicely with an increase in CO_2 occurring toward the end of the glacial period.

Isotopic geochemistry seems a very promising avenue for investigating climatic and paleoenvironmental change as well as for documenting the food and water sources used by various kinds of fossil mammals, and the method's potential is now widely recognized in the scientific community. As I mentioned earlier, when Dr. Cerling and I were beginning our research, it was difficult to persuade the average curator to part with even a small portion of fossil or modern enamel for the destructive analysis. Nowadays, the laboratories that are able to carry out this kind of work are in great demand.

In the next few years we look forward to using isotopic methods to refine our understanding of the climatic changes documented by the Rancho La Brea fossils.

DR. JOHN M. HARRIS
Chief Curator, Paleontology



PROGRAMS FOR MEMBERS AND VISITORS

LECTURES & SPECIAL EVENTS

Lecture and book signing

■ THE INVISIBLE INVADERS

Sunday, August 23, 2 p.m., Jean Delacour Auditorium, Museum of Natural History

Is the age of AIDS here to stay? Do viruses cause chronic fatigue syndrome and the controversial "yuppie flu" or is it all in the mind? How are viruses helping in the fight against nonviral diseases like skin cancer? Will there ever be a cure for the common cold?

Dr. Peter Radetsky has tackled these questions and many more in his book *The Invisible Invaders: Viruses and the Scientists Who Pursue Them* (Little, Brown, 1991). Now he gives us a fascinating look at science in progress as he describes the latest advances in the search for treatments, preventions, and cures for diseases caused by those not-quite-living entities called viruses. He will also discuss recent work in genetic research and engineering, where the potential of viruses for serving humankind is awe-inspiring. \$7 members, \$9 nonmembers, \$5 students with I.D.

10th annual Egyptian symposium

■ SEX, SORCERY, AND SECRETS

Alexander the Great in Egypt, and Akhnaten's Amarna

Friday through Sunday, September 25-27

Join us for a weekend of Egyptology co-sponsored by the Natural History Museum and the American Research Center in Egypt, Southern California Chapter. Spend three days exploring the mysteries surrounding two of the ancient world's greatest rulers, Alexander the Great and Akhnaten. Dr. Geoffrey Martin, Professor Emeritus of Egyptology at the University of London, chairs the sessions and will discuss the life of Akhnaten and the history of the Amarna period; he will also describe the mystery of the location of Nefertiti's tomb. Dr. William Murnane, Associate Professor of Ancient History at Memphis State University, will continue the discussion of Akhnaten by chronicling the religious revolution that he led and the introduction of monotheism into ancient Egypt.

Dr. Peter Kuhlmann, Director of the Oracle Temple Project in Siwa, will describe the fateful day that Alexander consulted the Egyptian oracle. Dr. Andrew Stewart, Professor of Art History at the University of California, Berkeley, will shed further light on the impact of Alexander on ancient Egypt.

A reception will be held on Friday, September 25, from 6 to 8 p.m.; the Saturday session is from 9 a.m. to 5 p.m., and Sunday's meeting is from 9 a.m. to 3 p.m. \$140 NHM/ARCE members, \$175 nonmembers, \$95 students (student admission does not include the evening reception).

Adult workshop

■ BEAUTY OF THE YEAST

Saturday, August 8 (beer) and 22 (mead), 9 a.m. to noon, Times Mirror Room, Museum of Natural History. Adults age 21 and older

Beers and meads are an amazing mix of hops, malt, and yeast—a microbe. Learn how the mixing is done with Brew Master Maribeth Raines-Casselman, who has developed her own commercial brew, Hollywood Blonde. Not only has she made brewing a hobby but as director of a microbiology research laboratory at UCLA, Dr. Raines-Casselman knows why some beers are good and others are great. In these classes, she will lead us in the scientific (and creative) process of making beer and mead. At the end of each workshop, you will go home with four bottles of microbrew and the knowledge needed to start your own home brewery. The Home Beer & Wine Making Shop is generously donating ingredients for the sessions. \$25 for each class, members; \$30 nonmembers

■ TWO TREATS FOR BOOK LOVERS

First, pick up your summer reading matter at the Natural History Museum's second annual book sale, sponsored by the Friends of the Library. The sale, which is open to everyone, will be held at the Exposition Park museum on Saturday, July 18, from 10 a.m. until 2 p.m.

Then, on Saturday, September 19, join the Friends of the Library for an evening of laughter and intrigue with a dinner perfor-

mance of the mystery, "The Reading of the Will." This first fund-raising event for the Friends will be held from 7 to 10:30 p.m. at the Anaheim Plaza Hotel; the cost is \$48 for FOTL members and \$55 for nonmembers and includes a full-course dinner, show, and parking. For reservations call 213/763-3388 before August 21; seating is limited, and early reservations are suggested.

The Friends of the Library not only supports the museum's Research Library but also provides its members with exciting activities and opportunities. A visit to a bindery, a train ride to the Santa Barbara Museum of Natural History, and a tour of the rare book collection at the UCLA Biomedical Library are some of the events the Friends have recently enjoyed.

For more information on the upcoming sale and dinner theatre, or to become a Friend of the Library, please call 213/763-3388.

ADULT FIELD TRIPS

■ A DAY IN WINE COUNTRY SOUTH

Saturday, July 18, 8:30 a.m. to 4 p.m. Adults age 21 and older

On this excursion to southern California's own wine country, we'll take a tour of the Callaway and Thornton wineries in Temecula and sample the wares. As we enjoy a gourmet picnic lunch beneath a grape arbor, we will learn what makes this area of the state so great for vineyards. Travel is by air-conditioned motorcoach; tour, wine-tasting, and lunch are included. \$65 members, \$75 nonmembers.

■ BIOLOGICAL ILLUSTRATION

Tuesdays, September 8 through November 10, 6 to 9 p.m., Education Classrooms, Museum of Natural History

Learn to create beautifully detailed and scientifically accurate images of a variety of plants and animals. Working with pencil, pen and ink, and watercolor, you will make use of stippling, line drawing, and shading in the fine art of biological illustration. Artist Frances Runyan, your instructor, has taught at the museum for more than 15 years; her paintings and drawings have appeared in books and scientific journals and are repre-

Walking tour

■ THE CANALS OF VENICE

Sunday, August 9, 9 to 11 a.m.

Elayne Alexander, author of *Abbott Kinney's Venice of America*, will lead us on a fascinating tour of this colorful southern California community. We will hear how Kinney came to found the town, with its network of waterways, and learn how it looked on its grand opening day in 1905. After viewing the canals, the Grand Lagoon, and the oil wells that led to Venice's prosperity in the early twentieth century, we will visit present-day attractions such as Muscle Beach. Ms. Alexander will share stories and photographs from the past and present that document Venice's enduring reputation as a free space for artists, dreamers, and rebels. \$20 members, \$25 nonmembers.

Photographs promoting the attractions of Venice, circa 1920. Courtesy Security Pacific National Bank Collection, Los Angeles Public Library.



sented in the collections of the Huntington Library, Carnegie Institute, and our own museum. All experience levels welcome. \$95 members, \$105 nonmembers.

■ BEERS, ALES, AND MICROBES

Saturday, August 15, 1 p.m. Adults age 21 and older only

On this special tour of Torrance's Southern California Brewing Company, Brew Master Branson Burrell will explain the role of microbes in the beer-making process, what wort and pitching are, and how fermentation works. Mr. Burrell will also share some of the secrets to making specialty brews. At the end of our tour, we will have the opportunity to taste some of the company's finest, including Alpine Hofbrau Bock, Olde Red Eye Red Ale, and Hefe Weizen. \$15 members, \$20 nonmembers.

CHILDREN'S CLASSES

Registration now open

■ ADVENTURES IN NATURE

July 13 to 17, July 20 to 24, July 27 to 31, and August 3 to 7, 10 a.m. to noon or 1 to 3 p.m., and August 10 to 14, 10 a.m. to noon. Museum of Natural History and Page Museum

Children from ages 3 to 13 learn about nature first hand in exciting participatory sessions with outstanding museum instructors. The week-long courses, which may be taken mornings or afternoons, offer opportunities to visit the curatorial laboratories, work with nature specimens, and make craft items to take home. While children are in class, adults may enjoy free museum programs. Children ages 14 and older are encouraged to apply for a limited number of Junior Volunteer positions, where they

will help instructors in classes and aid in lunchtime games and supervision.

Classes run Monday through Friday, mornings (10 a.m. to noon) or afternoons (1 to 3 p.m.); the August 10 to 14 classes are held in the mornings only. Children who are enrolled in both morning and afternoon classes will be supervised over the lunch break. Program costs are \$80 per week-long class for members; \$90 for nonmembers. Members receive additional discounts when enrolling two or more siblings. Children receive a special Adventures in Nature T-shirt with enrollment.

An Adventures in Nature brochure was sent to all members at the family level and above at the beginning of April. If you need additional information or are interested in sponsoring a child from an economically challenged family, please call 213/763-3534.

PROGRAMS FOR MEMBERS AND VISITORS CONTINUED

FAMILY FIELD TRIPS

FOSSIL HUNTING IN RED ROCK CANYON

Friday through Sunday, October 9 to 11.

Open to families with children of all ages

Search for fossils with Curator Dr. Dave Whistler, the only paleontologist with a collecting permit for Red Rock Canyon. We'll take nature hikes, learn about the unique geology of the region, and roast marshmallows around the evening campfire. And parents can relax while Helen Whistler prepares all three meals on Saturday and breakfast on Sunday. You provide transportation and camping gear, we'll take care of the rest! Arrive anytime after noon on Friday. Members: \$80 child, \$110 adult; nonmembers: \$90 child, \$120 adult.

FAMILY PROGRAMS

Family weekend workshops

INVISIBLE INVADERS, AMAZING ALLIES!

Saturdays and Sundays in July and August,

11:30 a.m. to 12:30 p.m. or 2 to 3 p.m.,

**Microbes Theater, ground floor, Museum of
Natural History**

In these special free sessions, you can learn more about the various roles that microbes play in people's lives. We'll be introduced to the microbes that help make our favorite foods; we'll find out what some are busy doing on our kitchen countertops and in our refrigerators; and we'll look at ways to prevent illnesses caused by the creatures that we call "germs." These workshops, to be led by experts from science and industry, will foster a healthy respect for the microscopic forms that are all around us and so essential to earth's well-being.

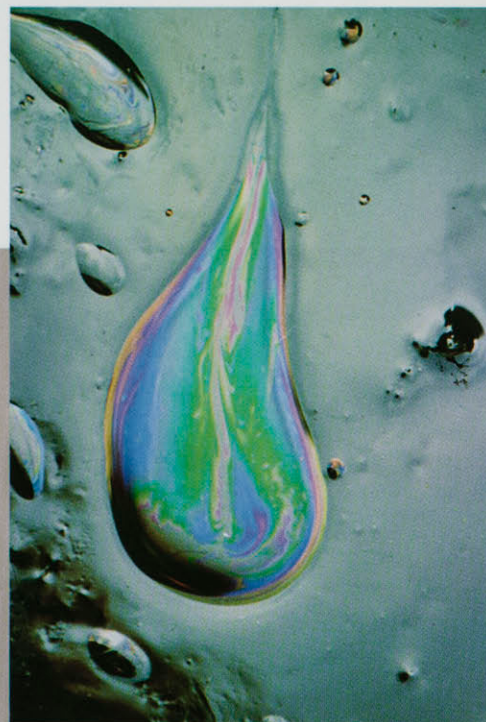
There are five different presentations—Dining with Microbes, Corraling Cooties, Spoiled Rotten, Hasta La Vista, Microbes, and The Dirt on Microbes; each will be presented several times over the course of the summer. For recorded information on the workshops planned for a particular weekend, please call 213/763-DINO.

Beauty in the Tar Pits

At the surface of Pit 91 in Hancock Park, oil and water interact. Richard F. Wheeler, an artist who has also been senior excavator for the Page Museum, has photographed the patterns that result.

Rain, dew, and the park's sprinkler system supply the water, and variations in temperature through the days and seasons in Hancock Park set the asphalt at the top of the pit in motion. Methane bubbles up in a continuous slow escape, water and the more volatile components of the liquid petroleum evaporate, and crusts are formed and pushed about by air currents. And sunlight reflects and refracts off of this activity, producing an ever-changing spectrum of color.

Mr. Wheeler's photographic work requires patience and dexterity. His



every step produces a sucking sound, and if he pauses on a warm day for more than 30 seconds, he has to pry his foot up out of the asphalt. A quick movement can result in a slippery fall—the fluid tar is only several inches thick, but it stains clothes nicely. The photographer can hang from the pit's shoring to get the angle that he wants, but he must always be careful to stay off the "sacred ground," the floor of the excavation where fossils are exposed and waiting to be removed.

On July 16, Pit 91 reopens for the 2-month annual excavations. The dig, which will continue until September 6, can be observed by visitors to Hancock Park; summer guided tours begin at 1 p.m. daily.



Sleepover

CAR DREAMS!!!

Overnight, Saturday and Sunday, September 26 to 27, 7 p.m. to 8:30 a.m., Petersen

Automotive Museum. Children ages 5 and older with accompanying adult

Get your Petersen learner's permit for "overnight driving" as we back up to the early 1900s and then zoom toward the future of the automobile. You will take a flashlight tour through the museum's vault, cruise the back alleys of Los Angeles in the Streetscape exhibitions, create car

craft items to take home, and tell car stories. An evening snack and breakfast are included; bring a sleeping bag and air mattress. \$40 members, \$50 nonmembers.

Halloween sleepover

BOO & GOO AT THE TAR PITS

Overnight, Saturday and Sunday, October 24 to 25, 7 p.m. to 8:30 a.m., Page Museum.

Children ages 5 and older with accompanying adult

Join in on the second annual sleepover among the amazing bones and fossils at the

FAMILY FUNDAYS

These family programs are free with museum admission for children ages 4 and older. No reservations are necessary, but space in some programs is limited, so please arrive early.

■ DECOMPOSER DEPOT

Saturday, July 18, 1:30 p.m., Discovery Center, Museum of Natural History

Discover how microbes and other creatures turn our leftovers into nutritious soil. Then take home a mini-decomposer.

■ WHAT'S MAKING YOU SICK?

Saturday, August 8, 1:30 p.m., Discovery Center, Museum of Natural History

With a team of microbiologists from UCLA, learn how doctors and other scientists discover which tiny little microbe is making someone sick.

■ CLOTHESPIN CAR

Saturday, July 25, 2 p.m., Artopia, Petersen Automotive Museum

How do you turn a clothespin into a car? Just add wheels, color, and a little creativity! Join us to find out how easy it is.

■ CEREAL BOX CAR

Saturday, August 29, 2 p.m., Artopia, Petersen Automotive Museum

Make sure to eat your cereal—you'll need that cereal box to create a car and give your toys a ride! Bring an empty rectangular box and we'll show you how to flame it!

Rancho La Brea tar pits. Celebrate Halloween with us as we take an after-hours tour of the museum, create some gooey crafts, and meet some live nocturnal animals with Wildlife on Wheels. We'll also trick-or-treat by flashlight through the mammoths, mastodons, and saber-toothed cats. Please wear your costumes for this fun-filled night. An evening snack and a light breakfast are included; participants provide their own sleeping bags and air mattresses. \$40 members, \$50 nonmembers.

■ MICROBES

Invisible Invaders, Amazing Allies

The hidden world of microbes is the focus of an exhibition on view through summer at the Museum of Natural History. *Microbes: Invisible Invaders, Amazing Allies*, takes visitors on a journey into the tiny landscapes and watery habitats of microscopic life forms. Through interactive displays featuring virtual reality, three-



dimensional animation, and special effects, families are introduced to various bacteria, viruses, microscopic fungi, and protozoa—including some notorious species that have earned the labels "germs" and "pathogens."

Microbes: Invisible Invaders, Amazing Allies, is a national traveling exhibition sponsored by Pfizer in collaboration with the National Institutes of Health.

PUBLIC PROGRAMS RESERVATION FORM

■ **By telephone:** Use your MasterCard or VISA. Call the Education Division at 213/763-3534, weekdays, 8 a.m. to 4 p.m. Credit cards are accepted only with a minimum charge of \$20.

■ **By mail:** Complete the form below, fill in the charge information or enclose a check payable to Museum Foundation, and return your order form and payment with a self-addressed, stamped envelope. The form may be duplicated. Mail to: *Education Division, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007*

■ **Important: Reservation, Waiting List and Refund Policies.** Preregistration is required for all classes, workshops, and field trips and is recommended for all other Education Division programs. Tickets to auditorium events may be purchased at the door on a first-come, first-served basis; seating is not reserved. Reservations are not necessary for Family Fundays. Applicants for filled programs will be placed on a waiting list and contacted if vacancies or rescheduling occur. If you have paid for a filled program, your payment will be refunded in 4-6 weeks.

Cancellations must be made at least 6 business days prior to the first day of an event for the registrant to be eligible for a partial refund. No refunds can be given for cancellations made in the 5 days before the event.

Dates and times of programs are subject to change, and class sizes are limited. Please call 213/763-3534 weekdays between 8 a.m. and 4 p.m. to verify program dates, times, and availability.

■ **Special Assistance Available.** If you wish to attend a museum event and require auxiliary aids or services, please contact the museums' Americans with Disabilities Act (ADA) Compliance Officer at least three (3) business days prior to the event. The ADA Compliance Officer may be reached by telephoning 213/763-3417 (voice) or by calling that number via California Relay Service at 800/735-2929 (TTY).

NAME (Please Print Clearly)		HOME ()		BUSINESS ()	
ADDRESS		CITY		STATE	
ZIP CODE					
Mail to:		Program		Number of participants	
Education Division				Price	
Natural History Museum				Total Price	
900 Exposition Blvd.					
Los Angeles, CA 90007					
☐ My check is enclosed					
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☐ MasterCard					
☐ VISA					
Credit Card # _____		Expiration Date _____		Total Remittance _____	
Signature _____					
Please list children's names, ages, and programs in which they are enrolling:					

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MUSEUM ON THE MOVE

■ AHMANSON FOUNDATION SUPPORTS INSECT ZOO

For the second year in a row, the Natural History Museum's Insect Zoo has been awarded \$50,000 from the Ahmanson Foundation. The grants have been made in support of the zoo's community outreach programs, in which museum instructors travel to schools and other community centers with presentations designed to introduce arthropods and explore their biology, diversity, and adaptations.

The Ahmanson Foundation was established in 1952 by Howard F. Ahmanson and his wife, Dorothy. The foundation concentrates its funding on projects related to culture, education, medicine, the environment, and human services and on organizations based in and serving the Los Angeles community.

■ GETTY MULTICULTURAL INTERNSHIPS

The Education Division has received \$10,200 from the Getty Grant Program to provide stipends for three undergraduate students to intern at the Natural History Museum over the summer. In making such grants, the Getty has the goals of increasing ethnic and cultural diversity in the professions related to museums and the visual arts while providing programmatic support for local organizations.

For 10 weeks, the interns will work alongside museum professionals; their tasks will include developing educational materials for the Discovery Center, enhancing the museum's website, assisting with the Insect Zoo's public outreach, and coordinating the Day of Sunshine program at the Page Museum.

From left to right, Dr. Vahe Simonian, Senior Vice President for Development, with Patricia Lombard, 1997-1998 Alliance Board President, and Lucy McBain, Rebecca Kubacki, and Angus McBain, the co-chairs of the museum's 1998 Dinosaur Ball. Photograph by Larry Reynolds.

The ball's theme, "An Evening of Treasures," highlighted the collections and the curators who bring them to life; museum supporters as well as our youngest visitors were honored. During the evening, curators

helped guests understand and appreciate the unique table centerpieces—items specially chosen from the museum's vast holdings for their beauty, rarity, public interest, or scientific significance. Guests at the gala also engaged in furious bidding at a silent auction, enjoyed hors d'oeuvres in the beautiful rotunda, dined in the mammals halls and around the Dueling Dinosaurs, and danced to two bands. Proceeds benefit the research and educational programs of the museum.



TRAVEL OUT OF THE ORDINARY ...

Get off the beaten paths, and discover worlds apart!

The Natural History Museum has an exciting new program of travel, with an array of unusual destinations and customized itineraries specifically tailored to our sophisticated Museum Members.

Each of our plans features an asset that only we can offer—you are accompanied on your trip by one of the museum's own experts, carefully chosen to add knowledgeable perspective and uncommon dimensions to your experience.

Contact our travel office today, and take the first steps toward an extraordinary adventure with the Natural History Museum.



**Biking, paddling, and hiking Kauai,
October 15-25, 1998
from \$2,675***

NEW MEMBERSHIP DIRECTOR



DICK MEER

Carmel Boerner has recently joined the Natural History Museum staff as director of membership. She will oversee the design and implementation of all aspects of the museum's membership program. Before coming to our museum, Ms. Boerner was membership manager at The Museum of Contemporary Art. She holds a B.Sc. in zoology and an M.B.A. in nonprofit administration from the University of British Columbia, Canada.

NEWS FOR MEMBERS

DOUBLE YOUR DONATION

Does your employer have a Matching Gift Program? If so, you may easily be able to double your support of the Natural History Museum. Ask your human resources department for information, or call our Membership Services Office at 213/763-3426.

RACES AROUND EXPOSITION PARK

During Labor Day weekend, September 5 to 7, a series of auto races will be held on the streets around Exposition Park. The course will actually circle the Museum of Natural History and several other park attractions, and we may be closed during the event.

For recorded information on hours and parking at the museum over the Labor Day weekend and in the days immediately preceding, please call 213/763-DINO.

GIFT MEMBERSHIPS AVAILABLE

Do you need a gift for someone who has everything? A membership in the Natural History Museum brings a number of exciting benefits, including a full year's worth of unlimited free admission to the Museum of Natural History, the Petersen Automotive Museum, the George C. Page Museum, and the William S. Hart Museum in Newhall. For more information, please call the Membership Services Office at 213/763-3426.



**The Pyrenees, from Barcelona
to Bilbao, Spain, October 16-31, 1998
from \$4,375***

To receive a detailed brochure on 1998 and 1999 museum travel opportunities or obtain more information about a specific destination shown here, please call Christine Robison at 213/763-3350. Or visit our Web page at www.nhm.org/travel.

**Cro-Magnon caves and
medieval French villages
September 16-25, 1998
from \$3,534***



**The subtropical wonders of the
Florida Everglades, November 16-23, 1998
from \$1,869***

Photographs copyrighted, used with permission: Kauai, Keith Karasic. Pyrenees, Jose Luis G. Grande. Gorge d'Enfer, France, Comité Départemental du Tourisme de la Dordogne. Florida Everglades, Lee Island Coast.

*Price per person, all accommodations and land transport included.

The Natural History Museum exists to advance knowledge and to enable people of all ages, backgrounds, and interests to understand and appreciate their natural and cultural heritage. The museum assembles, conserves, interprets, and holds in trust collections of irreplaceable objects from nature and human history. These collections reveal the history of the Earth and the evolution and diversity of life and culture. They sustain programs of research, exhibits, education, and publication.

Natural History Museum of Los Angeles County
World Wide Web: <http://www.nhm.org>

■ Museum of Natural History, Exposition Park
900 Exposition Blvd., Los Angeles 90007
General information 213/763-DINO

■ George C. Page Museum of La Brea Discoveries
5801 Wilshire Blvd., Hancock Park, Los Angeles 90036
General information 213/934-PAGE

■ Petersen Automotive Museum
6060 Wilshire Blvd., at Fairfax, Los Angeles 90036
General information 213/930-CARS

■ William S. Hart Museum
24151 San Fernando Road, Hart Park, Newhall 91321
General information 805/254-4584

Notice for materials in alternate format. If you require *Terra* or other printed information about the museums in an alternate format, please contact the museums' Americans with Disabilities Act (ADA) Compliance Officer at 213/763-3417 (voice) or by calling that number via California Relay Service at 800/735-2929 (TTY)

TERRA (ISSN 0040-3733) is published bimonthly by the Natural History Museum of Los Angeles County and sent as a benefit to museum members. ■ Produced by the Publications Office, Museum of Natural History, 900 Exposition Boulevard, Los Angeles, CA 90007. ■ For membership information, visit the Membership Office at the Museum of Natural History in Exposition Park or call 213/763-3426.

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NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
EXPOSITION PARK, LOS ANGELES, CALIFORNIA 90007

WE'RE FILLED WITH OOZE AND AHS.



And—for the next few months—we're surrounded by
landscape artists and backhoes!

A \$10 million renovation of Hancock Park is now underway. When the work is completed, in spring of 1999, visitors to the park will find beautiful paths and open spaces and rich new programs in natural history and art to enjoy.

Meanwhile, although portions of the park will be closed off sequentially during the work, the Page Museum of La Brea Discoveries will remain open throughout the construction project. Museum members and visitors can continue to marvel at the treasures that have been retrieved from the tar pits.

And on July 16, when the annual 2-month excavation in Pit 91 begins again, just to the west of the Page Museum, everyone will be able to see just how the smilodons and sloths and mastodons and mammoths are unearthed from the sticky tar where they've been preserved for 4,000 to 40,000 years!

Visit the Page Museum. It's the only way for you, your family, and your out-of-town guests to see what's been entombed in L.A. for millennia.



The Page Museum at the La Brea Tar Pits

5801 Wilshire Blvd., Los Angeles • On Museum Row • For information call (213) 934-PAGE